Mobile Computing Device
Map Display Enhancement and Route Navigation Test

FINAL REPORT

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Attachments:

Note: Due to the file size and paper volume required to include all attachments in this document, attachments are available upon request or on the Census Bureau's Decennial Management Division's Intranet Portal.

EXECUTIVE SUMMARY

Introduction--Field staff spend a large portion of their time planning routes and navigating to data collection sites. To minimize the effort devoted to this task, it is essential to maximize the ability of staff to use digital maps, particularly for those who are less skilled and/or uncomfortable using map resources. Results from two studies (Nusser and Fox, submitted; Census Bureau, 2002) indicate that field representatives exhibit a range of preferences for written directions (route-based thinkers) and graphical displays (map-based thinkers) on portable computers. These behaviors are consistent with spatial cognition theory, which predicts that conceptualization of geographical space varies in relation to an individual's knowledge of the area and spatial ability (Golledge 1991, Taylor and Tversky 1992).

These findings suggest that alternative presentation formats of route information should be developed for people with different spatial strategies, including text (route instructions) and visual (route path on map) formats. However, additional tools may be needed to further reduce interaction with the mobile computer when navigating. For map-based thinkers that prefer visual forms of spatial information, one approach is to use GPS to indicate the user's current position on the digital map. A second way in which GPS can be implemented is to trigger voice-delivered instructions to the driver, which may be more beneficial for route-based thinkers that prefer text instructions. Both strategies are hypothesized to minimize the interaction required with the mobile computer, reducing the cognitive effort devoted to navigation for the field staff.

Background--We designed a test to look at features that may assist field representatives (FRs) in using digital maps to find address locations. The context of the test was the 2010 Decennial Census, which is currently testing the feasibility of using handheld mobile computing devices (MCDs) equipped with digital map software and GPS. We pursued two general topics. First, we investigated recommended map interface enhancements from a previous map test. We explored these and evaluated them using various methods including group reviews with technical experts and a focus group with novice users. The final map interface was determined and base lined for the next phase of testing. The next phase looked at the utility of map features that provide users with additional context for interpreting current location and route instructions to ease the effort required to use the map. Features tested include a visual GPS position indicator, a visual display of a planned route, and voice delivery of route instructions. The experimental period was 3.5 days, and was conducted for groups of seven FRs during each of two weeks (November 17-20 and December 2-5, 2002). The study was designed to gather data on the performance, behaviors and reactions of FRs in response to five experimental settings, or treatments, that varied in the types of support for planning and navigation offered on a handheld computer. The five treatments were as follows:

Treatment #	Description
1.	Digital map with no additional information
2.	Digital map with pre-planned route information provided in two forms: as a highlighted path on the map, and as a written list of turn-by-turn directions for the route
3.	Digital map with GPS position indicator on the map
4.	Digital map with both pre-planned route information and GPS position indicator
5.	Voice-delivered on-the-fly driving instructions (with map and written turn-by-turn information)

The experiences of the FRs were measured in three ways. First, the FR's completed a background questionnaire before entering the field, a questionnaire after each assignment (or treatment), and two questionnaires to compare treatments 1-4 and to compare treatments 1-5 as a group. Second, an observer was assigned to each FR to ride along and record data about how they interact with the device, how the introduction of navigational aids impacts their work, and their ability to locate the assigned addresses during the different treatments. The observers tracked in-car experience using a customized in-car observation form, which tracked such things as time spent planning and navigating to addresses, and a GPS track log. The observers also completed a series of questionnaires, before entering the field, after completing each assignment, and after all assignments were completed. Third, a series of debriefings were conducted at the conclusion of the test.

We hypothesized that user response to these features would vary with the field representative's spatial strategy, suggesting that multiple presentation formats may be useful to maximize the performance of a large field staff. We also hypothesized that route-based thinkers would prefer the written or voice directions, whereas map-based thinkers would prefer map presentations of the route and make more effective use of the GPS position indicator. Please refer to Attachment A, Test Plan, as a reference for such specifics as term definitions, etc., while reviewing the results.

Findings–We found that there existed a level of enthusiasm and acceptance of this new technology in completing field operations. Also, there seemed to be good evidence that the current map display enhancements made between the first test in Gloucester County, VA and this test were used and did improve the map use. FRs mentioned on many occasions the device might improve their jobs because it would eliminate the volumes of paper their current procedures require. FRs suggested by integrating other functions, including address listing books and questionnaires, the Census Bureau could eliminate a lot of "stuff" (paper) currently used in their field work. The positive comments were not without some negative feedback. The major focus regarding disadvantages to the device dealt with its small display screen. Specifically, it was mentioned several times that the small screen was too crowded and some items ran together such as map spots, street names and/or feature names. There was some reference to screen glare being a problem. Also, limitations in the search functions for street addresses and too many steps required to find an address was a noted theme. Even though the FR background forms indicated 10 out of 14 FR's used a computer very often and most had used some kind of map software, it was stated that the MCD operation requires some level of practice to become comfortable and confident, as with any software.

We also found that when routes preplanned by a software were made available to the FR, the average planning time taken to determine where to go was roughly 10-20% of the time needed to perform planning when pre-planned routes were not available. This indicated the potential exists to save considerable staff time if a routing utility were available to determine routes for the FR.

Navigation aids were associated with improved performance for FRs in a variety of dimensions, including time spent reaching an address, the fraction of successfully completed addresses, and navigation errors. We found that the average time to get to an address is lower with the use of any navigation aid (GPS, route/directions or voice). In addition, estimated standard deviations for average travel time per address in an assignment indicated that the performance of FRs using all navigation aids (routes and GPS, except voice--treatment 4) was more consistent (less variable) than if some or no aids were used for the assignment (treatments 1-3). The number of addresses completed in the allotted time during the assignment was higher when routes/directions <u>and/or</u> GPS without voice (treatments 2-4) were provided relative to no navigation aid (treatment 1). Further, the mean number of addresses successfully found during the assignment was higher when GPS was used without voice (treatments 3 and 4) relative to no navigation aid (treatment 1). FRs were less likely to make navigation errors or get lost when routes/directions <u>and</u> GPS without voice (treatment 4) were provided relative to no navigation aid (treatment 1).

Regarding the critical Census Bureau issue of field staff safety, the test team went to great lengths to ensure that the MCD's were "not used while driving", included repeated messages during training, reminders on Assessment instruments, and the allowance for observers to ask FRs to return to the home base if they felt unsafe by the FRs driving techniques. However, based on the need to learn more about "what is really done" during field work, the observers collected information about safety behaviors. Differences among treatments for safe behaviors were not substantial, but results suggest that an initial increase in unsafe behaviors is seen with new technology, but that it is possible that these behaviors decline with increased usage. The tendency to look at the MCD while driving was significantly lower when given the map only (treatment 1) relative to a map with GPS (treatment 3) and the voice software (treatment 5). There was no real difference between maps only, maps plus routes, and maps plus routes and GPS (treatments 1, 2, 4) or among treatments 2-5. These results indicate that more frequent glances at the MCD were a potential burn-in effect for new technology that may subside in a second exercise with the new tool. There were no differences among treatments for frequency of pulling over to examine the device.

Regarding technical difficulties, they were significantly higher for the commercial voice software (treatment 5).

Recommendations--The test team used their specific experience gained during this project, as well as, the data collected and analyzed to make the following recommendations:
Regarding the use of electronic maps, the test team recommended the use of electronic maps for assignment location in a NRFU field operation for the 2004 Census Test.

Regarding the issue of Route Planning and Navigation aids, the test team did not recommend pursuing the use of provided map routes, turn-by-turn directions, or voice command navigational aids in the 2004 Census Test. We did recommend continuing research and testing into the subject for future implementation based on the findings of this test.

Regarding the use of Global Positioning System (GPS) for navigation, test team recommended the use of GPS technology as a navigational aid.

1.0 Background

As part of research, development, and planning for the 2010 Decennial Census, the Census Bureau explored the feasibility of using handheld electronic mobile computing devices to support the operational requirements of census field staff. Specifically, several feasibility studies were conducted to look at the mapping component of the operations. Also, since over 20 million map sheets were printed and deployed in Census 2000, another Census Bureau interest was to reduce the amount of paper and plotting needed for field operations. The expectation is that this state-of-the art technology can efficiently improve field data collection.

To do this, the Mobile Computing Devices (MCD) Working Group chartered an initial team to conduct electronic map feasibility testing using an MCD in February 2002. On February 11, 2002, staff from various Census Bureau subject matter areas met to begin planning this test. The test was conducted in Gloucester County, Virginia, from April 22, 2002 through May 3, 2002. The team's findings indicated that users can use maps displayed on a small electronic screen to navigate to and locate assignments. However, they recommended that further testing should address alternative approaches to displaying the map on the device and the possible use of automated route planning and navigational aides.

Following the recommendations, the MCD Working Group chartered a second team to conduct additional electronic map feasibility testing in July 2002. The team was tasked with the examination of the following, in priority order: 1) Map usability and map display software enhancements, and 2) Route planning and the use of navigational aides as a cognitive test. The team decided early that two separate testing components existed and would be titled and developed as follows (in priority order):

Component 1: MCD Map Display Enhancement

Component 2: Route Planning and Navigation

Regarding test Component 1, the test team decided that the Gloucester County, VA map test had proven that maps displayed on a three-inch screen can be used to navigate to and locate addresses. Therefore, the approach (approved by the MCD Working Group in August 2002) to developing and testing map enhancements suggested in the first tests' recommendations and reviewed them internally within the Census Bureau for feedback without retesting in the field. A sub-team was formed to determine the strategy to meet the objective and coordinated the review sessions. The details of this process are documented in Attachment A, Test Plan. The objective was to develop a baseline map for use in Component 2 testing. The following text focus on the field portion of the study.

2.0 Test Component 1–MCD Map Display Enhancement

2.1 Study Methods

The group determined that the Gloucester County, VA map test (April 2002) had proven that maps displayed on a three-inch screen can be used to navigate to and locate addresses. Therefore, our approach (approved by the MCD Working Group in August 2002) incorporated map display enhancements based on the first tests' recommendations and reviewed them for feedback without retesting in the field. Therefore, the following strategy was implemented to conclude a final baseline map for the field test:

<u>Sub-team Review</u>

- Continual individual review within sub-team until enhancements are considered ready.
- Group review (projected on screen) by sub-team to determine final enhancements.
- Enhancement comments incorporated.

<u>Test Team Review</u>

- Full test team review (projected on screen) via demo from sub-team.
- Test team members checked out MCDs with new application to "play" with them for a day or weekend, depending on timing and provide feedback to sub-team.
- Enhancement comments incorporated.

<u>Novice User Focus Group</u>

- Novice User Focus group was held with Census staff members with no census experience. During this focus group, participants were provided with a brief training, after which they had an opportunity to use the device in an exercise and participate in a debriefing about the map and the user map interface.
- Enhancement comments incorporated.

<u>MCD Working Group Review</u>

- Presentation given to the MCD Working Group in September 2002 for feedback.
- Enhancement comments incorporated.
- Test Component 1: Map display enhancements considered complete and

baselined for Test Component 2.

2.2 Results

Geography Division and other members of the Map Enhancement Sub-team performed a number of enhancements to the mapping component of the MCD test for Sussex County Delaware. These enhancements were based on recommendations from team members, MCD Working Group members, novice users during a focus group session, and the results of the MCD test in Gloucester, VA. The following is a summary of the mapping and display enhancements.

Enhancements <u>Made</u> To The ArcPad Mapping Component

Software and Interface

- Improved layout and arrangement of application menus and buttons
- Enhanced form menus to allow the display of map spot addresses
- Improved fonts used to label map features
- Improved map design and feature symbology
- Adjusted the scale dependent rendering values
- Added ability to identify items on the map by feature type
- Added an automated method for removing user drawings from map
- Added ability to turn-off the highlighting of features that are selected
- Changed the default layer for the map search tool to map spots
- Enhanced user interface when adding annotations
- Changed opening view to the assignment area and/or route extent for certain project files
- Added capability for displaying map spots labels

GPS and Routing

- Integrated GPS into ArcPad application
- Allowed GPS to track a user's current location
- Integrated routes and turn-by-turn directions into ArcPad application
- Created a method for toggling between the map and turn-by-turn directions

Enhancements <u>Not</u> Made To The ArcPad Mapping Component

The following is a list of suggested enhancements or changes to the mapping software component that were not implemented due to a variety of reasons.

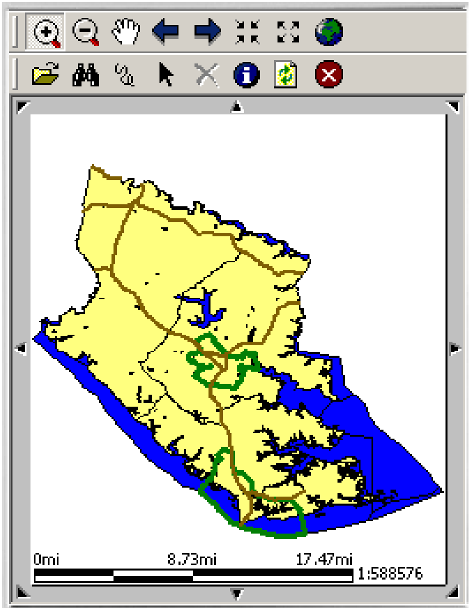
- The zoom-out tool in ArcPad has a bug where the software does not zoom-out as expected. It was recommended that this tool be removed and a new method for zooming-out be developed, but in order to provide the best interface, the zoom-out tool was used as is. In subsequent testing, the zoom-out problem did not happen that often and was not that severe.

- The interface for the mapping component could benefit from the use of index, inset and parent maps. This would require a great deal of effort to implement and it is not easily supported in the current ArcPad software environment.
- It was suggested that a set of fixed zoom levels could be developed which would allow the user to zoom in and out of areas more effectively. This would require a great deal of effort, and from a production standpoint, would not be feasible for an actual census operation. The density of features that are displayed on the maps varies greatly from one area to another, which would make this an intensive effort.
- It was suggested that address ranges be added to street segments. While this would be useful in some instances, it would be difficult to effectively label address ranges given the current map content, current software text placement capabilities, and the display area on the device. Address ranges were instead used in the street-id popup, where available.
- A recommendation as made to impute a user's location based on address ranges. Give the project schedule and scope, it was decided that this capability would not be implemented.
- A recommendation was made to change the highlight properties of the application interface buttons. This is not possible with the current operating system of the device and the current ArcPad software.
- From the Novice User Focus Group it was recommended that a "notes" section should be added to the application via a drop down menu to allow field workers to make wording notes such as "return at 5:00 tonight", or "beware of dog". It was decided that this functionality would be useful, but for the purposes of the test and due to timing, it was not implemented.
- From the Novice User Focus Group it was recommended that an on-line help feature be added to the ArcPad software. This was not implemented and classroom training of field representative would lessen the need for this functionality.
- From the Novice User Focus Group it was suggested that users would benefit from showing tracts and blocks on the map. Given the complexity of existing maps, clearly symbolizing and labeling these entities would be challenging. This is especially true give the limited amount of screen "real estate". Users can, however, use the identify function to determine tract and block numbers.
- From the Novice User Focus Group, it was recommended to eliminate the labeling of divided highways multiple times since this often resulted in overprinting and illegible text. Chaining of like features for naming purposes was performed, but given the nature of the database, eliminating all of these instances

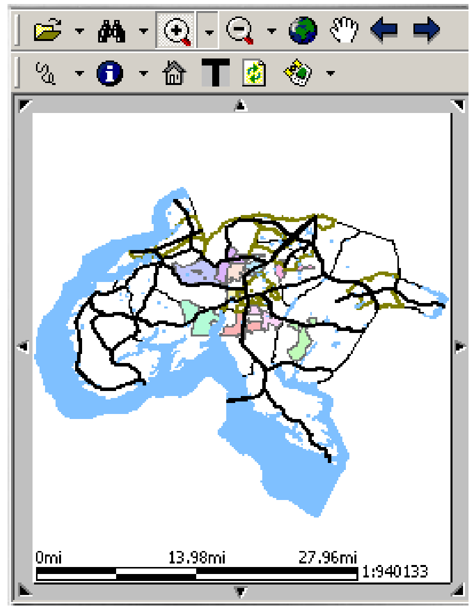
is not possible at this time. Furthermore, the text placement functionality of the software leaves a lot to be desired.

The following illustrations (beginning on next page) depicts enhancements made in a side-by-side comparison between the first maps used in the Map Usability Test in Gloucester County, VA and the current test in Charles County, MD and Sussex County, DE.

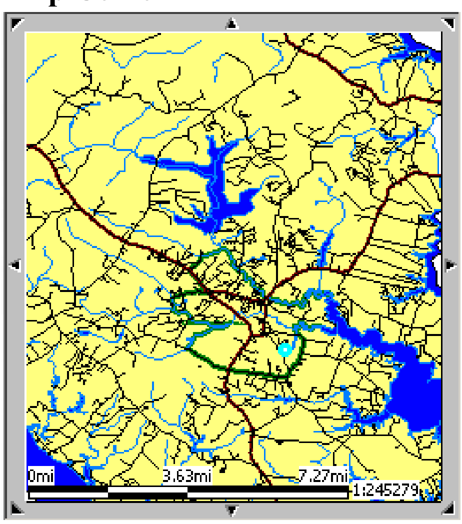
1A. Gloucester VA - Initial View



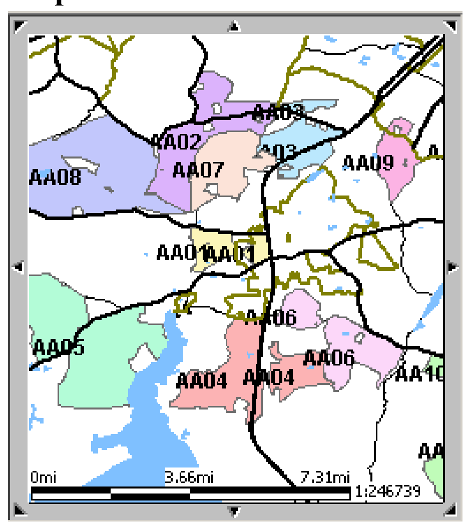
1B. Charles MD - Initial View



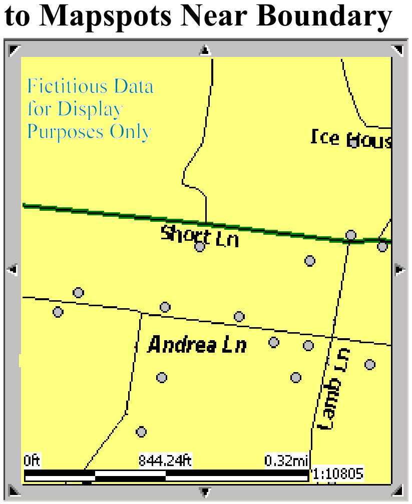
2A. Gloucester VA- Zoomed into Map Center



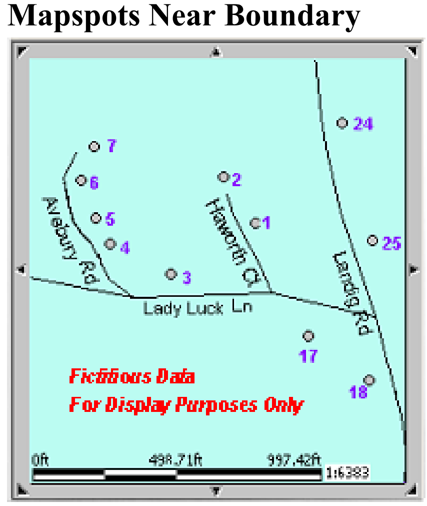
2B. Charles MD- Zoomed into Map Center



3A. Gloucester VA-Zoomed to Mapspots Near Boundary



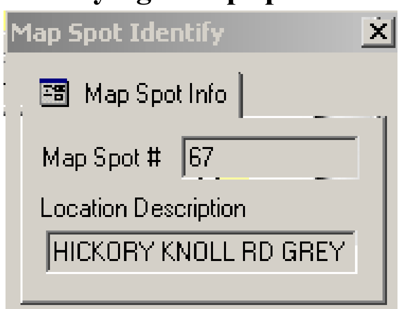
3B. Sussex DE-Zoomed to Mapspots Near Boundary



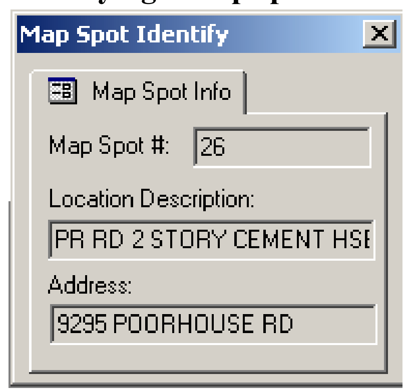
4A. Gloucester VA - ArcPad Toolbar
- Contains 16 Functions
- Simple "Locked Down" Design

4B. Charles MD - ArcPad Toolbar
- Contains 25 Functions
- Simple "Locked Down" Design
- Utilizes Drop Down Menus
- Incorporates Flow of Users Tasks

5A. Gloucester VA - Pop-up box which results from identifying a map spot

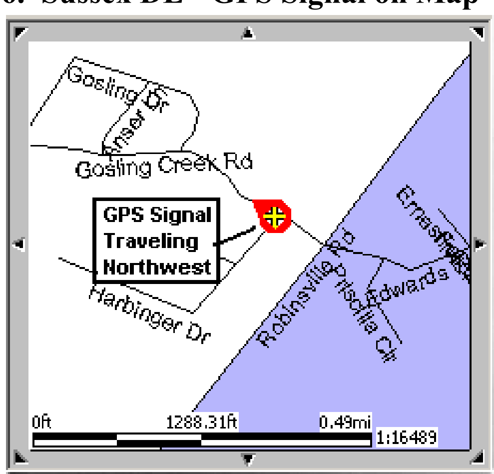


5B. Charles MD - Pop-up Box which results from identifying a map spot



Example of GPS Signal on Map:

6. Sussex DE - GPS Signal on Map



3.0 Test Component 2–Route Planning and Navigation

3.1 Study Plan/Experimental Conditions

The study was designed to gather data on the performance, behaviors and reactions of FR in response to five experimental settings that varied in the types of support for planning and navigation offered on a handheld computer. The five treatments were as follows:

Treatment #	Description
1.	Digital map with no additional information
2.	Digital map with pre-planned route information provided in two forms: as a highlighted path on the map, and as a written list of turn-by-turn directions for the route
3.	Digital map with GPS position indicator on the map
4.	Digital map with both pre-planned route information and GPS position indicator
5.	Voice-delivered on-the-fly driving instructions (with map and written turn-by-turn information)

Each FR was given a planning and navigation task that involved verifying a set of six addresses for each one of these treatments. The treatments were given in the order given above, with new address assignments for each treatment.

The handheld device used for the study was an iPAQ 3970 with a 3” x 2” high resolution color screen interface. The handheld device was equipped with a GPS receiver for treatments 3-5.

For treatments 1-4, the base map was constructed from updated TIGER, the Census Bureau’s internal mapping database system and Master Address File (MAF) files for Sussex County. ArcPad was used to display map spots on TIGER maps for treatments 1-4. The ArcPad interface was adapted to provide tools and display styles appropriate for this study, as recommended by the Map Display Enhancement subteam (Test Component 1). In addition to standard view tools for geospatial data, FRs could perform searches to identify an address and sketch annotations on the map.

Routes for treatments 2 and 4 were generated manually with ESRI Arc 8 software, using Microsoft Streets & Trips software as a reference. Written turn-by-turn directions were provided to the user in a Word interface. A toggle was provided for simple access to both map-based and written directions.

For treatment 5, Co-Pilot navigation software was used with a commercial map. Co-Pilot automatically generates routes for a set of destinations, which are provided in a highlighted map and written list form. In addition, a GPS receiver is used to track the user's position in relation to the route, triggering audio driving cues (e.g., "turn right") during navigation. If the user deviates from the planned route, the route is automatically reconfigured on-the-fly by the software and the driver is redirected using the new route. A limited visual display is offered during driving.

FRs were offered just-in-time training for the equipment and software prior to the initial use of each tool. Prior to starting the study with treatment 1, training was provided for operating the handheld device and ArcPad software. Prior to treatment 2, FRs were trained to interpret the routes on the map and to toggle between written instructions offered in Word and map interface displayed by ArcPad. FRs were trained on GPS use prior to treatment 3, and on Co-Pilot prior to treatment 5.

As noted earlier, two tasks were performed by each FR for each of the five experimental conditions. First, the FR planned a route for six addresses in an assignment area. In treatments 2, 4 and 5, where visual routes and written directions were available, the proposed route was part of the information that could be used to plan a route; for other treatments, only the digital map was available. The second task involved driving to the assignment area, and then trying to locate and verify each housing unit on the address assignment list for a treatment.

To develop the address assignment areas, seven residential neighborhoods were selected from the area surrounding Rehoboth Beach. The assignment area consisted of six addresses on distinct streets in close proximity to one another. Areas were selected so that they would be as similar as possible to one another. Within each assignment area, six addresses were identified. These addresses were field verified as representing existing housing units with visible addresses. An unanticipated complication was that the Rehoboth area was transitioning to 911-style addresses at the same time the study was conducted so that some addresses were modified between the time they were field verified and the time when the study was conducted. FRs were advised of this fact.

Assignment areas were allocated to FR-treatment combinations for a single week using an incomplete Latin square. This ensured that only one FR was assigned to an area during a specific treatment (avoiding contamination from the presence of other FRs during a treatment regimen), and that an FR only went to an assignment area once during the field study (avoiding a confounding effect of familiarity that would occur if the FR had visited the assignment area for a prior treatment).

3.2 Observational Protocols

Several assessments were obtained during the course of the study. On the first day of the study, information was gathered via questionnaire on the prior map-based survey experience of FRs, their familiarity with the study area, their current methods of identifying housing unit locations, and their preferences for map and route-based materials.

An observer was assigned to each FR for the duration of the study to record information on FR behaviors. Observations recorded during each treatment included time spent planning the assignment, time to reach each address, the frequency of navigational errors and other navigation and safety behaviors such as pulling off the road, and conditions that might lead to unexpected delays in navigation.

Post-treatment evaluation questionnaires were administered immediately following each treatment exercise to each FR and observer. The questionnaires included questions to assess the effectiveness and problems associated with each treatment.

In a final assessment to obtain comparisons among treatments, a questionnaire evaluating treatments 1-4 as a group was administered to each FR and observer after completing treatment 4. Similarly, after completing treatment 5, a questionnaire was given to each FR and observer to evaluate the full set of treatments.

Questionnaires and forms were reviewed during the study and missing data were retrieved from the FR or observer when possible. Data were entered using double key entry (key and verify) to create data sets for analysis. Prior to analysis, tables and listings of the data were reviewed to identify and correct if possible any additional problems in the data.

Two problems occurred during the first week of the experiment that may have affected the data and required adjustment during the analyses. First, an error was discovered in the route listing for the address that had been assigned to FR 7 during treatment 2 that caused the FR to fail at finding an address. These data were omitted from analyses comparing data from each treatment. Second, the map processing speed on treatment 1 during week 1 was found to be very slow. The base map was clipped so that the responsiveness of the map software was improved for subsequent treatments during week 1 and all treatments during week

2. A variable was included in the analysis model to account for this effect so that week 1 data for treatment 1 data could be retained.

At the end of the study, a standard test of spatial visualization ability, the VZ-2 paper-folding test from the *Kit of Factor-Referenced Cognitive Tests* (Ekstrom, et al., 1976), was administered to each FR. There were some problems in the consistency of administration of these tests, and in week 2, poor weather prevented the administration of the test to some of the FRs. It was decided that the data could not be used for meaningful analysis.

3.4 Analyses

The primary data for evaluating treatment differences were obtained from in-car observations for each treatment. A mixed model approach was used to account for differences in address assignments and the slow map effect for treatment 1, week 1. A linear model was assumed in which address assignment and week effects were designated as random, and treatment effects and the effect of the slow map effect for treatment 1, week 1 were designated as fixed. Although this model could be improved upon for some variables (e.g., number of addresses completed per assignment), this approach is used to report initial results. An F-test was used to detect differences among treatments. Least squares means were calculated for each treatment. If a treatment difference was detected via the F-test at $\alpha = 0.10$, then pairwise t-tests were calculated for each treatment pair. A Tukey adjustment was made to the p-values to account for multiple comparisons between pairs of treatments. For one in-car observation variable (time to complete address assignment), the variances varied across treatments. In this case, homogeneity of variance tests were performed using an adjustment for multiple comparisons.

The same modeling and testing approach was used to analyze data from post-treatment evaluations completed by FRs and observers for each treatment.

The remaining assessments correspond to the background information on each FR, and the comparative evaluations for treatments 1-4 and for 1-5. For these evaluations, only one form was filled out by each FR and by each observer (rather than a separate questionnaire for each treatment). Frequencies, means and standard errors were used to summarize results from these questionnaires.

3.5 Results

In this section, we focus on the key findings of the study. Tables supporting the results are presented in each subsection.

3.5.1 Field representative (FR) background information

Prior to the beginning of the study, FRs completed a background questionnaire. The results are summarized briefly in this section.

FRs who participated in this experiment were primarily older adults, with half in their 70s, six in their 50s and 60s, and one in her/his 40s. There were six males and eight females.

All but one FR had participated in a past decennial census. Only four FRs had worked for the Census Bureau for less than two years, but more than two months; all others had more than two years of experience. Six of the FRs had been to the Rehoboth area often, although only four of them indicate that they were reasonably familiar (score of 4 or 5) with the side roads.

Ten FRs had used a computer very often, three sometimes, and one a few times. No FRs had used handheld computers before. Most had used some kind of map software, with nine who used map software sometimes or more frequently. Only one FR had ever used a GPS receiver and no one had used in-car navigation systems.

When asked about their relative use of maps and written directions when finding address assignments, three FRs indicated they used mainly written directions, two used both, eight used mainly maps, and one FR used only maps.

All FRs generally felt moderately or very confident about driving in unfamiliar areas during their assignments (mean score on a five-point scale = 4.14, SE = 0.21). Eight FRs indicated some level of distraction by maps and other materials when they were driving in unfamiliar areas, with five indicating at least a moderate level of distraction (mean score on a five-point scale = 2.07, SE = 0.30).

3.5.2 Treatment comparisons from in-car observations

The primary variables used to assess differences among treatments were FR behaviors recorded by observers during each treatment assignment. For tables presented in this section, least squares means and standard errors are provided, plus indicator of multiple comparison results (treatments with distinct letters are significantly different from each other). The p-value for the treatment F-tests are also presented.

When routes preplanned by the software were made available to the FR (treatments 2, 4, 5), average planning time taken was roughly 10-20% of the time needed to perform planning when pre-planned routes were not available (treatments 1, 3) (Table 1). These results indicate that the potential exists to save considerable staff time if a routing utility were available to determine routes for the FR.

Table 1. Treatment means, standard errors, and multiple comparison results for planning time in minutes (p-value: <0.0001).

Treatment	Estimated Mean (minutes)	Standard Error	
1 Maps only	57.2	2.6	A
2 Map + route/directions	5.9	2.7	B
3 Map + GPS	58.8	2.6	A
4 Map + route /directions+ GPS	8.7	2.6	B
5 Map voice software	5.7	2.7	B

Navigation aids were associated with improved performance for FRs in a variety of dimensions, including time spent reaching an address, the fraction of successfully completed addresses, and navigation errors.

The average time to reach an address is lower with the use of any navigation aid (GPS, route/directions or voice) (Table 2). In addition, estimated standard deviations for average travel time per address in an assignment indicated that the performance of FRs using all non-voice navigation aids, routes and GPS (treatment 4), was more consistent (less variable) than if some or no aids were used for the assignment (treatments 1-3) (Table 3). F-tests for homogeneity of variances indicated that this difference is significant at $\alpha = 0.05$.

Table 2. Treatment means, standard errors, and multiple comparison results for the average time to reach an address in minutes/address (p-value: 0.001).

Treatment	Estimated Mean (minutes / address)	Standard Error	
1 Maps only	18.0	1.5	A
2 Map + route/directions	11.0	1.5	B
3 Map + GPS	12.4	1.5	B

Treatment	Estimated Mean (minutes / address)	Standard Error	
4 Map + route /directions + GPS	10.1	1.5	B
5 Map voice software	12.6	1.5	B

Table 3. Estimated standard deviation for mean travel time per address by treatment (multiple comparisons computed for variances at $\alpha = 0.05$).

Treatment	Estimated Standard Deviation for Mean Travel Time per Address	
1 Maps only	6.47	A
2 Map + route/directions	5.25	A
3 Map + GPS	5.35	A
4 Map + route /directions + GPS	2.60	B
5 Map voice software	7.22	A

The number of addresses completed during the assignment was higher when routes/directions and/or GPS without voice (treatments 2-4) were provided relative to no navigation aid (treatment 1) (Table 4). Although FRs noted that they had completed addresses, in fact some of these addresses had not been accurately located in the field. Table 5 indicates that the mean number of addresses correctly located during the assignment was higher when GPS was used without voice (treatments 3 and 4) relative to no navigation aid (treatment 1) (Table 5).

Table 4. Treatment means, standard errors, and multiple comparison results for the number of addresses completed during the assignment (p-value: 0.02).

Treatment	Estimated Mean (# addresses / assignment)	Standard Error	
1 Maps only	4.79	0.26	A
2 Map + route/directions	5.78	0.26	B

Treatment	Estimated Mean (# addresses / assignment)	Standard Error	
3 Map + GPS	5.71	0.26	B
4 Map + route /directions + GPS	5.86	0.26	B
5 Map voice software	5.53	0.26	AB

Table 5. Treatment means, standard errors, and multiple comparison results for the mean number of addresses correctly located during the assignment (p-value: 0.005).

Treatment	Estimated Mean (addresses located correctly / assignment)	Standard Error	
1 Maps only	4.45	0.32	A
2 Map + route/directions	5.55	0.31	B
3 Map + GPS	5.71	0.30	B
4 Map + route /directions + GPS	5.86	0.30	B
5 Map voice software	5.29	0.31	AB

FRs were less likely to make small navigation errors or get lost when routes/directions and GPS without voice (treatment 4) were provided relative to no navigation aid (treatment 1) (Tables 6 and 7).

Table 6. Treatment means, standard errors, and multiple comparison results for the frequency of small navigation errors (p-value: 0.01).

Treatment	Estimated Mean Score	Standard Error	
1 Maps only	1.75	0.11	A
2 Map + route/directions	1.48	0.11	AB
3 Map + GPS	1.55	0.11	AB
4 Map + route /directions + GPS	1.33	0.11	B
5 Map voice software	1.51	0.11	AB

Scale: 1 = Never, 2 = 1-3 Times, 3 = Several Times

Table 7. Treatment means, standard errors, and multiple comparison results for the frequency of getting lost (p-value: 0.07).

Treatment	Estimated Mean Score	Standard Error	
1 Maps only	1.333	0.077	A
2 Map + route/directions	1.157	0.077	AB
3 Map + GPS	1.149	0.075	AB
4 Map + route /directions + GPS	1.067	0.077	B
5 Map voice software	1.114	0.077	AB

Scale: 1 = Never, 2 = 1-3 Times, 3 = Several Times

Differences were not substantial among treatments for the frequency with which FRs glanced at the MCD while driving and pulled off the road to use the MCD. Some results suggest that an initial increase in glancing behaviors is seen with the introduction of new technology, but that these behaviors may decline with increased exposure to the tool. The tendency to look at the MCD while driving was significantly lower for the map only option relative to GPS only and voice software, while there was no difference between maps only, maps plus routes, and maps plus routes and GPS (treatment 1, 2, 4) or among treatments 2-5 (Table 8). These results indicate that more frequent glances at the MCD were a potential burn-in effect for new technology that may subside in the second exercise with the new tool. There were no differences among treatments for frequency of pulling over to examine the device (Table 9).

Table 8. Treatment means, standard errors, and multiple comparison results for the frequency of looking at the MCD while driving (p-value: 0.05).

Treatment	Estimated Mean Score	Standard Error	
1 Maps only	1.23	0.15	A
2 Map + route/directions	1.54	0.15	AB
3 Map + GPS	1.59	0.15	B
4 Map + route /directions + GPS	1.51	0.15	AB
5 Map voice software	1.59	0.15	B

Scale: 1 = Never, 2 = 1-3 Times, 3 = Several Times

Table 9. Treatment means, standard errors, and multiple comparison results for the frequency pulling off the road to look at the MCD (p-value: 0.47, not significant).

Treatment	Estimated Mean Score	Standard Error	
1 Maps only	1.684	0.092	A
2 Map + route/directions	1.691	0.095	A
3 Map + GPS	1.744	0.092	A
4 Map + route /directions + GPS	1.750	0.092	A
5 Map voice software	1.564	0.095	A

Scale: 1 = Never, 2 = 1-3 Times, 3 = Several Times

The frequency of technical difficulties was generally low, and significantly lower for maps with routes/directions only or maps with GPS only relative to voice software (Table 10).

Table 10. Treatment means, standard errors, and multiple comparison results for the frequency of technical difficulties (p-value: 0.02).

Treatment	Estimated Mean Score	Standard Error	
1 Maps only	1.077	0.045	AB
2 Map + route/directions	1.013	0.047	A
3 Map + GPS	1.024	0.045	A
4 Map + route /directions + GPS	1.107	0.045	AB
5 Map voice software	1.218	0.047	B

Scale: 1 = Never, 2 = 1-3 Times, 3 = Several Times

3.5.3 Treatment comparisons from post-treatment evaluations

After completing an assignment/treatment combination, FRs and observers completed a post-treatment evaluation form, recalling experiences during the assignment. Where appropriate, questions were repeated for each treatment, and questions on the observer survey instrument mirrored those on the FR questionnaire. Selected results are presented in this section. Tables include least squares means and standard errors, plus indicator of multiple comparison results (treatments with distinct letters are significantly different from each other).

FR responses indicated that they used the information resources provided to them in expected ways (Table 11). For example, FRs relied on map resources more often when only a map was provided or when GPS without voice was available (treatments 1, 3, 4) relative to when only route information or voice-based route information was provided (treatments 2, 5). Hand-drawn sketches on the MCD map were relied upon more heavily when no route was available (treatments 1, 3) relative to when route information was provided (treatments 2, 4). Directions provided on the MCD were relied on more when no voice output was available (treatments 2, 4) relative to when voice-delivered directions were available (treatment 5). Handwritten directions were relied upon more heavily when no route was available (treatments 1, 3) relative to when route information was provided (treatments 2, 4, 5). Finally, FRs indicated a heavier reliance on GPS (treatments 3, 4) when TIGER maps were provided relative to the voice-based software (treatment 5). On the voice software, GPS was used to automatically generate routes on the fly, but was not a major feature of the visual interface, and thus was likely used less often.

Table 11. Treatment means, standard errors, and multiple comparison results from FR post-treatment evaluations for the degree to which FRs relied on the MCD map, their own sketches on the MCD map, turn-by-turn directions on the MCD, their own written directions, and the GPS position indicator (all p-values: <0.001).

	Rely on Maps			Rely on Own Sketches on Maps		
Treatment	Estimated Mean Score	SE		Estimated Mean Score	SE	
1 Maps only	4.64	0.26	A	3.57	0.27	A
2 Map + route/directions	2.75	0.27	B	1.09	0.28	B
3 Map + GPS	4.57	0.26	A	4.00	0.27	A
4 Map + route /directions + GPS	4.36	0.26	AC	1.00	0.27	B
5 Map voice software	2.43	0.26	BC	--		

Scale: 1 = Not at all, 3 = Somewhat, 5 = A great deal

	Rely on MCD-Provided Directions			Rely on Own Written Directions		
Treatment	Estimated Mean Score	SE		Estimated Mean Score	SE	
1 Maps only	--			3.29	0.35	A
2 Map + route/directions	4.91	0.25	A	1.62	0.36	B
3 Map + GPS	--			3.86	0.35	A
4 Map + route /directions + GPS	4.86	0.24	A	1.32	0.36	B
5 Map voice software	3.50	0.24	B	1.00	0.35	B

Scale: 1 = Not at all, 3 = Somewhat, 5 = A great deal

	Rely on GPS Position Indicator		
Treatment	Estimated Mean Score	SE	
1 Maps only	--		
2 Map + route/directions	--		
3 Map + GPS	4.36	0.28	A
4 Map + route /directions + GPS	4.07	0.28	A
5 Map voice software	2.71	0.28	B

Scale: 1 = Not at all, 3 = Somewhat, 5 = A great deal

FRs indicated that the routes were more effective when any non-voice navigation aid was present (treatments 2-4) relative to the map only treatment or voice software treament (treatments 1 and 5) (Table 12). Observers indicated that the routes were more effective when any navigation aid was present (treatments 2-5) relative to having the map only (treatment 1). This is consistent with other performance measures in this study that indicate the increased effectiveness of providing supplementary map-based resources such as routes and/or a GPS position indicator to FRs in this setting.

Table 12. Treatment means, standard errors, and multiple comparison results for the effectiveness of routes used in assignments, as rated by field representatives (FR, p-value: 0.001) and observers (OB, p-value: 0.0002).

	FR Rating			OB Rating		
Treatment	Estimated Mean Score	SE		Estimated Mean Score	SE	
1 Maps only	3.00	0.26	A	2.57	0.27	A
2 Map + route/directions	4.31	0.27	B	4.08	0.28	B
3 Map + GPS	4.21	0.26	B	3.71	0.27	B
4 Map + route /directions + GPS	4.43	0.26	B	4.36	0.27	B
5 Map voice software	3.64	0.26	A	3.64	0.27	B

Scale: 1 = Not well at all, 3 = Moderately well, 5 = Extremely well

FRs and observers noted that the FR was more likely to deviate from the route planned by the FR with no navigational aid (treatment 1) relative to when navigational aids were provided (Table 13). FRs indicated that more deviations occurred for treatment 1 relative to any non-voice navigational aid (treatments 2-4). Observer data indicate that fewer deviations occurred for treatments for which a route was provided (treatments 2 and 4). These results are consistent with results cited previously that show reduced driving error rates when navigational aids are provided to FRs.

Table 13. Treatment means, standard errors, and multiple comparison results for the frequency that FRs deviated from planned routes, as rated by field representatives (FR, p-value: 0.02) and observers (OB, p-value: 0.01).

	FR Rating			OB Rating		
Treatment	Estimated Mean Score	SE		Estimated Mean Score	SE	
1 Maps only	3.07	0.30	A	3.50	0.35	A
2 Map + route/directions	2.15	0.31	B	2.42	0.36	BC
3 Map + GPS	2.15	0.30	B	2.79	0.35	AC
4 Map + route /directions + GPS	1.86	0.30	B	2.29	0.35	BC
5 Map voice software	--			--		

Scale: 1 = Never, 3 = Sometimes, 5 = Very often

Data on distractions and potentially unsafe driving behaviors indicated a reasonably low occurrence of such behaviors, and that differences among treatments were generally small to nonexistent. For example, FRs indicated a low level of distraction and tests indicated that there was no difference among treatments in how frequently FRs felt they were distracted by their handheld computers (Table 14). These scores are similar in magnitude to the mean pre-test score cited in Section 3.1. Observers rated the frequency of distraction as being somewhat lower than FRs, and results from observer ratings indicated that the frequency of distraction was slightly higher for treatments 4 and 5. Other observer ratings on safety behaviors indicated that their occurance was reasonably low, that there was no difference among treatments in the driving risks taking by FRs, and that FRs tended to interact with the device less frequently for the map only treatment (treatment 1) relative to all other treatments (Table 14).

Table 14. Treatment means, standard errors, and multiple comparison results for safety behaviors.

a. The frequency that FRs were distracted by the handheld computer, as rated by FRs (p-value: 0.71, not significant) and observers (p-value: 0.03).

	FR Rating			OB Rating		
Treatment	Estimated Mean Score	SE		Estimated Mean Score	SE	
1 Maps only	1.71	0.27	A	1.21	0.27	A
2 Map + route/directions	2.10	0.28	A	1.69	0.27	AC
3 Map + GPS	1.93	0.27	A	1.71	0.27	AC
4 Map + route /directions + GPS	1.86	0.27	A	1.86	0.27	BC
5 Map voice software	2.00	0.27	A	2.00	0.27	BC

Scale: 1 = Never, 3 = Sometimes, 5 = Very often

b. Observer ratings of the frequency that FRs took driving risks (p-value: 0.57, not significant) and interacted with the device (p-value: <0.0001).

	FR Rating			OB Rating		
Treatment	Estimated Mean Score	SE		Estimated Mean Score	SE	
1 Maps only	1.21	0.16	A	1.43	0.34	A

Treatment	FR Rating			OB Rating		
	Estimated Mean Score	SE		Estimated Mean Score	SE	
2 Map + route/directions	1.06	0.17	A	2.43	0.35	B
3 Map + GPS	1.29	0.16	A	2.43	0.34	B
4 Map + route /directions + GPS	1.43	0.16	A	2.71	0.34	B
5 Map voice software	1.29	0.16	A	3.07	0.34	B

Scale: 1 = Never, 3 = Sometimes, 5 = Very often

FR self-reported frustration levels were reasonably low. Their ratings were highest with the voice delivery of route instructions (treatment 5) and tended to be lower for the MCD map with a navigation aid (treatments 2-4), although not all of these differences were significant (Table 15). Observer ratings more clearly indicated a higher frustration level for FRs when no navigation aid was provided or voice software was used (treatments 1, 5) relative to when a navigation aid was provided on the TIGER maps (treatments 2-4).

Table 15. Treatment means, standard errors, and multiple comparison results for the frustration level of FRs, as rated by field representatives (FR, p-value: 0.001) and observers (OB, p-value: 0.002).

Treatment	FR Rating			OB Rating		
	Estimated Mean	SE		Estimated Mean	SE	
1 Maps only	2.57	0.29	AB	3.00	0.28	A
2 Map + route/directions	1.59	0.30	CD	1.92	0.29	B
3 Map + GPS	1.71	0.29	CB	2.00	0.28	B
4 Map + route /directions + GPS	1.36	0.29	CD	2.00	0.28	B
5 Map voice software	2.71	0.29	A	2.86	0.28	A

Scale: 1 = Not at all frustrated, 3 = Somewhat frustrated, 5 = Extremely frustrated

FR self-reported confidence levels were reasonably high, and test results indicated that FR confidence was generally higher when using the MCD navigation aid (treatments 2-4) relative map only or voice software (treatments 1, 5), although not all of these differences were significant (Table 16). Results from tests on observer ratings indicated that FR confidence levels were higher when route information and a GPS position indicator were provided (treatment 4) relative to map only (treatment 1). These results are also similar to the mean confidence score reported by FRs prior to the study (Section 3.1).

Table 16. Treatment means, standard errors, and multiple comparison results for the confidence level of FRs, as rated by field representatives (FR, p-value: 0.0001) and observers (OB, p-value: 0.06).

	FR Rating			OB Rating		
Treatment	Estimated Mean	SE		Estimated Mean	SE	
1 Maps only	2.93	0.28	A	2.79	0.32	A
2 Map + route/directions	4.51	0.29	B	3.62	0.33	AB
3 Map + GPS	4.07	0.28	BC	3.50	0.32	AB
4 Map + route /directions + GPS	4.50	0.28	B	4.14	0.32	B
5 Map voice software	3.57	0.28	AC	3.36	0.32	AB

Scale: 1 = Not at all confident, 3 = Somewhat confident, 5 = Extremely confident

3.5.4 Treatment comparisons from final evaluations

After treatments 1-4 had been completed, FRs and observers were asked to evaluate the alternative navigation aids as a whole. A similar evaluation was performed after completing all five treatments. Count data and mean scores with standard errors were tabulated from each evaluation for FRs and observers.

Results from both FR and OB ratings for treatments 1-4 indicated that the MCD map with route/directions and GPS position indicator is considered the most effective combination of navigation aids for finding assigned addresses (Table 17a). Similar results were observed when treatments 1-5 were evaluated in that a majority of FRs and observers still rated the MCD map with route/directions and GPS position indicator as most effective, although some FRs and observers felt the voice software was most effective (Table 17b). For both evaluations, providing only a MCD map was considered the least effective treatment.

Table 17. Number of responses indicating the most and least effective treatment, as rated by field representatives (FR) and observers (OB) for (a) treatments 1-4 as a group and (b) treatments 1-5 as a group.

a. Comparison of treatments 1-4

	Most Effective Navigation Setting		Least Effective Navigation Setting	
	FR	OB	FR	OB
1 Maps only			13	13
2 Map + route/directions	4	2		1
3 Map + GPS		2	1	
4 Map + route /directions + GPS	10	10		

b. Comparison of treatments 1-5

	Most Effective Navigation Setting		Least Effective Navigation Setting	
	FR	OB	FR	OB
1 Maps only			13	13
2 Map + route/directions	1			
3 Map + GPS	1	1		
4 Map + route /directions + GPS	7	9		
5 Map voice software	5	4	1	1

When evaluating the helpfulness of the MCD map only (treatment 1) or maps provided via the voice software (treatment 5) in relation to maps provided by The Census Bureau to FRs as part of their usual survey data collection activities, both the MCD map and the voice software options were rated by most FRs to be more helpful for planning and traveling than Census maps used in their previous Census assignments (Table 18).

Table 18. Number of responses, mean score, and standard error indicating the helpfulness of MCD maps in general and voice software relative to maps previously provided by The Census Bureau for field assignments, as rated by FRs.

	MCD maps in Relation to Previous Census Bureau Maps		Voice Software in Relation to Previous Census Bureau Maps	
	Planning	Traveling	Planning	Traveling
1 Much less helpful	1	1	1	1
2	3	2	2	1
3 About the same	1	3	2	
4	4	2	3	3
5 Much more helpful	5	5	6	8
Average score	3.64	3.62	3.79	4.23
Standard error	0.37	0.38	0.37	0.36

When comparing the use of routes on the map and turn-by-turn directions on the TIGER maps (treatments 2, 4) in relation to MCD maps without navigation aids (treatment 1), a clear majority of FRs and observers found the routes and directions to more helpful than the MCD map by itself (Table 19).

Table 19. Number of responses, mean score, and standard error indicating the helpfulness of map routes and turn-by-turn directions for planning and traveling, as rated by FRs and observers (OB).

	Routes on Map and Turn-by-Turn Directions on TIGER (treatments 2,4) in Relation to MCD Map Only (treatment 1)					
	FR Ratings				OB Ratings	
	Routes on Map		Turn-by-Turn Directions		Routes on Map and Turn-by-Turn Directions	
	Planning	Traveling	Planning	Traveling	Planning	Traveling
1 Much less helpful			1			
2			1		1	1
3 About the same	3	3	2	1	3	3
4	1	2	1	2	3	4
5 Much more helpful	10	9	9	11	6	6
Average score	4.50	4.43	4.14	4.71	4.08	4.07
Standard error	0.23	0.23	0.36	0.16	0.29	0.27

Results were less clear when comparing voice software (treatment 5) to the MCD maps only treatment (treatment 1). FR and observer responses were not definitive about which setting was best, and observers tended to have a lower opinion of the voice software (Table 20).

Table 20. Number of responses, mean score, and standard error indicating the helpfulness of map routes and turn-by-turn directions for planning and traveling, as rated by field representatives (FR) and observers (OB).

	Routes on Map and Turn-by-Turn Directions from Voice Software (5) in Relation to Routes on Map and Turn-by-Turn Directions on TIGER (2,4)					
	FR Ratings				OB Ratings	
	Routes on Map		Turn-by-Turn Directions		Routes on Map and Turn-by-Turn Directions	
	Planning	Traveling	Planning	Traveling	Planning	Traveling
1 Much less helpful	1	1	2	2	1	1
2	3	2	3	1	3	6
3 About the same	4	4	5	3	7	2
4	2	2	1	2	2	3
5 Much more helpful	4	5	3	6		2
Average score	3.36	3.57	3.00	3.64	2.77	2.93
Standard error	0.36	0.36	0.36	0.40	0.23	0.34

When comparing the use of the GPS position indicator on the TIGER map for traveling (treatments 3, 4) in relation to traveling with map without GPS (treatments 1, 2), nearly all FRs and observers felt that the GPS was more helpful in their traveling than the map without a GPS position indicator (Table 21).

Table 21. Number of responses, mean score, and standard error indicating the helpfulness of the GPS position indicator relative to using the map without the GPS position indicator, as rated by field representatives (FR) and observers (OB).

	GPS Position Indicator (3,4) in Relation to MCD Map Without GPS (1,2)

	FR	OB
1 Much less helpful		
2		
3 About the same	1	1
4	4	6
5 Much more helpful	9	7
Average score	4.57	4.43
Standard error	0.17	0.17

Once again, results were more mixed when comparing GPS with the TIGER map and the voice software. When comparing the use of the GPS position indicator displayed by the voice software (treatment 5) in relation to the TIGER map with GPS position indicator (treatments 3, 4), results were mixed for FRs and observers about which setting was more helpful (Table 22).

Table 22. Number of responses, mean score, and standard error indicating the helpfulness of the voice software GPS indicator relative to the TIGER-based position indicator, as rated by field representatives (FR) and observers (OB).

	Voice Software GPS Position Indicator (5) in Relation to TIGER GPS Position Indicator (3,4)	
	FR	OB
1 Much less helpful		1
2	2	3
3 About the same	7	6
4		4
5 Much more helpful	4	
Average score	3.46	2.93
Standard error	0.31	0.25

3.5.5 Summary of Data Analysis

The Gloucester field study conducted in April 2002 demonstrated that it was feasible to use handheld computing devices for Decennial Census address verification activities. The Sussex County, Delaware study investigated whether providing GPS and routing information offer benefits to field staff when performing similar tasks. Delaware study results indicate that providing either a GPS position indicator or routing information to the FR is likely to result in improved productivity.

Improved planning performance occurred only when the routing information was provided on the MCD to the FR. At the current time, TIGER does not have the street and intersection data elements (e.g., indicators for a one-way street or no left turn intersection) required to perform computer-based route determination. Thus, routing functions can only be provided via a separate software package with its own map database. The trade-off between the costs of providing such software and the savings resulting from improved performance was not part of this study, but would need to be considered.

Improved navigational performance occurs when either routing information or GPS position indicator information are provided to the FR. In this setting, both aids appear to offer more support for finding and verifying the location of an address than if a digital map is used by itself. FRs rely on various supporting tools in the manner that would be expected, indicating that in general, they are making effective use of the route and GPS information. The time reduction generated by providing routing and/or GPS may be due in part to a reduction in navigational errors relative to providing only a TIGER map to the FR.

An interesting sidelight is that providing both routing information and a GPS position indicator resulted in fewer navigational errors and more consistent driving times across FRs relative to having either the route information or the GPS position indicator. We hypothesized that offering multiple resources enables FRs with different spatial strategies to use their preferred information format for navigation. Spatial visualization assessments were not available to explore this hypothesis further.

When asked to compare the digital maps, routes and GPS with Census Bureau maps used during their usual assignments, FRs indicated that digital maps were slightly better than the paper maps. FRs noted that providing planning and navigation aids increased the utility of the digital maps to the point of being clearly more helpful than paper maps.

Although FRs were excited by the promise provided by voice software, the voice software used in this study was not suitable for the address verification task. It is worth exploring whether voice delivered instructions helps compensate for those who prefer written directions, and how it impacts the risk associated with using handheld computer tools for navigation.

Safety was an additional area considered during this study. Results indicate that MCD-related distraction levels reported by FRs during the experiment are similar to the distraction levels they reported prior to the beginning of the study when asked about using paper maps in unfamiliar settings. Additional results on potentially risky driving behaviors suggest reasonably low incidence rates and that there is little difference in behaviors among treatments.

3.5.6 Summary of the Debriefing Sessions

This summary is derived from the final debriefing summary report prepared after the test. The complete report can be found in Attachment I.

<u>Treatments 1-4</u>

- The FR's felt that they were able to use the MCD's to find assignments during the field test.
- The FR's that invested in planning their routes before entering the field felt that they experienced a greater success rate in locating assignment addresses and that they completed their assignments in less time than not.
- The FR's complained that the device processing speed hampered their use of the MCD. Their concentration was broken and time was wasted due to the machines slow processor.
- The FR's felt that the GPS was an important feature and that value was gained in several ways depending on the FR. Some found the GPS useful in knowing where they were at, while others relied on it to determine their travel direction.
- The FR's all experienced having to adjust their view of the map when GPS was engaged. Most notably when FR's were zoomed in to tight the screen would automatically shift to maintain the GPS icon at the center of the screen, preventing FR's from viewing sections of the map if not zoomed out sufficiently.
- The FR's using the annotation features to label assignments and mark their routes found the feature very useful and shorten their time in the field.
- The FR's felt the small screen hampered their ability to distinguish street names and other markings.

- The FR's all experienced touching the screen unintentionally without the stylus causing them to lose their place, they believe the screen was too sensitive.

- The FR's felt the ability to toggle between written directions and maps were a great benefit.

<u>Treatment 5</u>

- The FR's felt most confident when using the voice actuated directions, but that their confidence was quickly undermined when the software failed to perform correctly. This resulted in FR's sometimes not being able to recover because they had not invested in pre-route plan during this treatment.

- The FR's felt no need to invest in pre-planning a route given their expectations with the voice component. Their expectation was that the device would instruct them and they would need only to follow.

- The FR's felt that they interacted less with the device in-car with the voice component.

- The FR's desired more control over the device to control with the voice component such at repeat, speed or mute buttons.

In conclusion, the greatest increase in accuracy, timesavings and user satisfaction came as a result of planning before entering the field. Therefore, it could be said that the MCD is a useful tool that can supplement users construction of mental maps but should stop short of eliminating the fundamental of step of planning that is essential for user understanding and effectiveness. This follows research around orientation and navigation performance of 3D interfaces by Avi Parush (Israel Institute of Technology). During his presentation at the University of Maryland in which he pointed out that effort must be exerted in the creation of individual mental pictures. In addition, that spatial cognition is based on landmarks, routes (streets) or survey information (maps) to construct references to support trip planning.

4.0 Acknowledgments

As the project manager, my aim is to honor the influence of the people most closely connected to this project for their commitments and contributions that have made this test

a success. This test was only accomplished by the remarkable way the entire test team, including folks not specifically mentioned below, worked so well together with many representatives taking on tasks to ensure its success.

Andrea Johnson (FLD) was a constant driving force that maintained a work ethic on this test that was incredible. Her proactive participation and creative thinking really helped jump start this test when we were struggling to develop the basic testing plan and framework to accomplish the research we were asked to do. She routinely went beyond the call of duty to ensure the test remained on schedule and of top quality. I thank her for her enthusiasm and willingness as a consultant on almost any related issue that arose. I'd like to recognize Jerry Coleman (GEO) for the tremendous work he did related to the MCD map programing and getting the mapping software "enhanced" and ready for our testing. Also, Jerry did an unbelievable job as our "technical support" guru while in Sussex Co., DE. There were no equipment-related problems that affected the test. Thanks for your hard work and dedication. I'd like to thank and recognize Jennifer Harrop (GEO) for the wonderful and timely job she did in selecting and creating our assignments and producing all the assignment area maps used for reference and demonstration purposes. She could count on her work being needed by "yesterday" and the team could count on her delivering it right away and of the highest quality.

A special thanks goes to our "equipment manager" Frank Bush (DSCMO) for his outstanding work in managing and supporting all of the MCDs, including preparing the MCD kits and the complex training room set-up needed at the training location. Frank, we couldn't have had a successful test without fully charged and ready-to-go devices each morning. Nice job Frank. Thanks to Harry Rodriquez for his tremendous efforts in evaluating and helping select our navigation software. It was a thankless job that Harry performed well. Thanks to Bob Bakondi (DMD) for loaning his expertise from the previous map feasibility test in Gloucester County VA and for coordinating, writing, and conducting the manual and training for the observers. Special thanks and recognition to Greg Brivic, Vicki Lewis, and Phil Lutz of the Philadelphia Regional Office for all of their efficient and timely work to recruit and coordinate all of our field testers and field activities. Myron Smith (DMD), an intern working with us from the Illinois Institute of Technology did a tremendous job in coordinating, with Susan Ciochetto and Joe Cortez (CASRO), and facilitating the final debriefings. Special thanks to Myron for his personal quest to video tape and photograph the operation for permanent record and reference. He was right, pictures are worth a thousand words and have been used many times for presentation. As mentioned prior, Susan and Joe (CASRO) assisted with the debriefing plan development and compiling and making sense out of all the final debriefing notes, then producing the final debriefing report on a very tight deadline. Thanks a lot.

We couldn't have produced any test results without the tremendous work and assistance

we obtained from Sarah Nusser and staff from Iowa State University. Their expertise, assistance, and support were critical puzzle pieces in the test design and data collection area. Linda Anderson at the Iowa State University Center for Survey Statistics and Methodology assisted in the analyses. Jan Larson at the Iowa State University Center for Survey Statistics and Methodology assisted in developing the data collection forms. Thanks so much for all your hard work.

Finally, special thanks to all the Field Representatives and observers that took on the roll of "testers" and "observers" to help us better understand the feasibility and practicality of such new and groundbreaking technology here at the United States Census Bureau. Thanks to everyone that contributed to this test.

(Note: The contributions of Sarah Nusser and staff at the Iowa State University Center for Survey Statistics and Methodology were funded in part by the Census Bureau via an IPA and by NSF Digital Government Grant Number EIA-9983289. The Digital Government Grant is jointly funded by NSF, Census Bureau, U.S. Department of Agriculture, and U.S. Geological Survey to investigate methods for using geospatial data in mobile computing environments. The Census Bureau IPA supported extensions of research conducted under the Digital Government project to Census Bureau settings.)

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